

CHAPTER 3
AIRWORTHINESS STANDARDS
TRANSPORT CATEGORY ROTORCRAFT

MISCELLANEOUS GUIDANCE (MG)

AC 29 MG 1. CERTIFICATION PROCEDURE FOR ROTORCRAFT AVIONICS EQUIPMENT.

a. Pre-Test Requirements.

(1) General. This test guideline has been prepared as an aid in the evaluation of rotorcraft avionics (aviation electronics) equipment installations. The criteria presented are not to be considered exclusive, but are offered as one method of evaluating design practice and performance. The testing and qualification of an electronic installation should be considered as consisting of three phases: preinstallation, ground, and flight. The amount of testing necessary during each phase will vary with the amount of testing performed on previous phases. For example, if a system is TSO'd, the preinstallation performance is probably substantiated and therefore the ground and flight testing can be reduced accordingly. Also, a thorough ground testing program should result in reduction in necessary flight testing. When the operating or airworthiness regulations require a system to perform its intended function, the use of TSO'd equipment or the submission of data substantiating the equipment performance is strongly recommended.

(2) Regulatory References. Sections 29.1301, 29.1309, 29.1329, 29.1331, 29.1333, 29.1355, 29.1431, 29.1457.

(3) System Design. Systems or equipment presented for installation approval, when not qualified by TSO or other approval means, should be accompanied by sufficient data to substantiate their design acceptability.

(i) Operation of Controls. The operation of controls intended for use during flight, in all possible position combinations and sequences, should not result in a condition that would be detrimental to the continued safe performance of the system.

(ii) Electrical Shock. Systems should be designed so that under all probable conditions the risk of dangerous electrical shock is minimized.

(iii) Fire Hazard. The design of the system should be such that all components meet the applicable fire and smoke protection requirements of §§ 29.853 and 29.863. Cables and equipment to be installed in designated fire zones, that are used during emergency procedures should be at least fire resistant.

(iv) Plugs and Cables. Connector pins for sensitive signal circuits should not be adjacent to pins used for AC power circuits. When redundant wiring is used to

comply with the systems independence regulations such as §§ 29.1331, 29.1333, or 29.1355, the wires should be routed through separate plugs and/or cables with as much physical separation as practicable. The system should be designed so that incorrect mating of plugs is not possible. Cable grounding and shielding techniques should be used to minimize electromagnetic interference.

(4) System Performance. Where the operating or airworthiness regulations require a system to perform its intended function, and when the equipment is not qualified by TSO or other approval means, performance data furnished to the FAA/AUTHORITY can reduce the installed performance testing. The appropriate TSO minimum performance standard may be used as a guide.

(i) Environment. An appropriate means for environmental testing is set forth in Radio Technical Commission for Aeronautics (RTCA) document DO-160. The applicant should submit test reports showing that the laboratory tested categories such as temperature, vibration, altitude, etc., are compatible with the environmental demands to be placed on the rotorcraft.

(ii) Failure Analysis. Procedures are contained in paragraph AC 29.1309, section c of this advisory circular.

(5) Installation Design

(i) Mechanical Installation. Installations should be made to (1) ensure compliance with the airworthiness regulations and (2) comply with the equipment manufacturer's recommendations. The designer should observe good engineering practices in specifying material type, thickness, fastener type, edge distance, and attachment to the equipment rack. By analysis or static tests the mounted equipment should be shown to withstand the inertia forces of §§ 29.561(b)(3) and 29.337. Refer to AC 43.13-2a for static test procedures.

(ii) Arrangement and Visibility. The mounting position of all instruments, switches, position labels, and control heads should make them plainly visible to the pilot while in his normal panel-facing position and under all cockpit lighting conditions likely to occur. TSO approval does not assure instruments will be acceptable in a particular cockpit installation or for all lighting conditions. The instruments, switches, and placarding must be free from reflections. Malfunction annunciation devices should be conspicuous and clearly visible to the pilot. (See Advisory Circular 20-69 and §§ 29.1321, 29.771, 29.1381, and 29.1555(a).)

(iii) Load Analysis.

(A) Power Sources. It should be determined whether the electrical power source capacity is adequate for the system installation under all foreseeable operating conditions including engine failure on multiengine rotorcraft. System load reductions should be applied or power source capacity increased if necessary to assure

compatibility between load and source. Duplicate systems should be powered from separate buses and, in some cases, from independent sources if required by the airworthiness regulations. (Sections 29.1309, 29.1331, 29.1333, 29.1351, or 29.1355.)

(B) Navigation Course Deviation Circuit Loading. It should be determined that the deviation circuit source impedance is matched by its load and that the source capacity is not exceeded. When the system is capable of transfer, the transfer loads should also be considered (§ 29.1301).

(C) Malfunction Indicator Circuit Loading. It should be determined that the malfunction indicator source impedance is matched by its loads and that the source capacity is not exceeded. When the system is capable of transfer, the transfer loads should also be considered (§ 29.1301).

(D) Synchro Signal Loading. When parallel loads are added to Synchro's, the manufacturers' specifications should be reviewed to assure that the additional loads do not result in an overloaded synchro.

(iv) Interface. In many cases, the mating units of a system are designed by different manufacturers. For example, a brand-X gyro may be designed for operation with a brand-X flight director, but later a modifier decides to operate a brand-Y autopilot with the brand-X gyro. This applies just as well to NAV receivers, AREA NAV units, course indicators, omni bearing selectors, tachometer indicators, transmitters and many other equipment items. When this is the case, the applicant should provide data, in summarized form, describing those characteristics such as impedance, volts, etc., that are necessary to assure a compatible and reliable system. The data should also reference the source of the interface data (§ 29.1301).

(v) Flight Tests. An FAA/AUTHORITY engineering flight test is required during type certification or after modification that changes the established limitations, flight characteristics or performance of a rotorcraft or any of its required systems or operating procedures. New installations of equipment in the cockpit or modifications that affect existing equipment in the cockpit should be evaluated by appropriate flight test personnel, if it is necessary to evaluate operational aspects of the change. Where possible, cockpit arrangement, placards, markings, instrument visibility, and light reflections can be evaluated on the ground if the applicant opts to darken the windows. Electromagnetic compatibility functional checks, windshield glare, and pilot workload evaluations may be conducted in flight at the FAA/AUTHORITY flight test pilot's option.

(vi) Radio Master Switches. Some installations incorporate radio master switches to control special busses for the avionics systems. If this capability is provided it should be evaluated to assure failure modes are not introduced that will result in excessive or even total loss of all required avionics. One switch that controls all required avionics is not considered acceptable for IFR installations. The evaluation should include an assessment of the loss of the systems to be included on the radio master switch(es), and the subsequent effect on continued safe flight.

b. Test Procedures. Where the airworthiness or operating regulations require a system to perform its intended function, and/or not create a hazard to other required systems, sufficient testing should be accomplished to assure satisfactory performance. When ground testing is not sufficient to properly evaluate a system's performance, flight testing should be accomplished. Acceptable flight test criteria for specific navigation and communication equipment are contained herein. If the rotorcraft is to be approved for IFR operations, the additional criteria of AC 29 Appendix B should be satisfied.

(1) VHF Systems.

(i) General. Intelligible communications should be provided between the rotorcraft and ground facilities throughout the airspace within 100 NM of an FAA/AUTHORITY ground facility from radio line of sight altitude to the maximum altitude for which the rotorcraft is certificated. Communication should be provided with the rotorcraft at or above line of sight altitude in right and left bank up to 10 degrees and on all headings.

(ii) Electromagnetic Compatibility (EMC). With all systems operating in flight, verify by observation that no adverse effects are present in the flight systems.

(iii) Antenna Measurement. If satisfactory antenna measurement data are provided, the following flight test may be reduced to checks in right and left turns in the vicinity of the predicted bearings of worst performance. If antenna locations are symmetrical, tests may be conducted using only one direction of turn.

(A) Long Range Reception. Starting at a distance of at least 100 NM from the ground facility antenna, perform a right and/or left 360 degree turn at a bank angle of at least 10 degrees. Communicate with the ground facility every 10 degrees of turn to test the intelligibility of the signals received at the ground station and in the rotorcraft. For 100 NM, the minimum line of sight altitude is approximately 7,000 feet.

(B) Approach Configuration. With the landing gear down and with the rotorcraft in the approach configuration (at a distance of 10 NM from the ground station and in an idle power descent toward the station), demonstrate intelligible communications between the rotorcraft and the ground facility.

(2) HF Systems.

(i) Acceptable communications should be demonstrated by contacting a ground facility at a distance of at least 100 nautical miles. Single sideband equipment should also perform acceptably in the amplitude modulation mode of operation.

(ii) It should be demonstrated that precipitation static is not excessive when the aircraft is flying at cruise speed (in areas of high electrical activity, including

clouds and rain if possible). Use the minimum amount of installed dischargers for which approval is sought.

(3) VOR Systems.

(i) These flight tests may be reduced if adequate antenna radiation pattern studies have been made and these studies show the patterns to be without significant holes (with the rotorcraft configurations used in flight, i.e., landing gear retracted en route and extended for approach). Particular note should be made in recognition that certain rotor RPM settings may cause modulation of the course deviation indication (rotor modulation). VOR performance should be checked for rotor modulation in both approach and en route operation while varying rotor RPM throughout its normal range.

(ii) The airborne VOR system should operate normally with warning flags out of view at all headings of the rotorcraft (in level flight) throughout the airspace within 100 NM of the VOR facility while flying above the radio line of sight altitude to within 90 to 100 percent of the maximum altitude for which the rotorcraft is certified.

(iii) The accuracy determination should be made such that the indicated reciprocals agree within 2 degrees. Tests should be conducted over at least two known points, on the ground, such that data are obtained in each quadrant. Data should correlate with the ground calibration and in no case should the absolute error exceed ± 6 degrees. Fluctuation of the course deviation indication should not be excessive.

(A) En route Reception. Fly from a VOR facility, rated for high altitude, along a radial to a range of 100 NM. The VOR warning flag should not come into view, nor should there be deterioration of the station identification signal. The course width should be 20 degrees (± 5 degrees tolerance, 10 degrees either side at the selected radial). If practical, perform en route segment on a doppler VOR station to verify the compatibility of the airborne unit. Large errors have been found when incompatibility exists.

(B) Long Range Reception. Perform a 360-degree right and a 360-degree left turn at a bank angle of at least 10 degrees at an altitude just above radio line of sight (see b(1)(iii)(A) for line of sight altitude) and at a distance of at least 100 NM from the VOR facility. Signal dropout should not occur as evidenced by the malfunction indicator appearance. Dropouts that are relieved by a reduction of bank angle at the same relative heading to the station are satisfactory. The VOR identification should be satisfactory during the left and right turns.

(C) En route Station Passage. Verify that the To-From indicator correctly changes as the rotorcraft passes through the cone of confusion above a VOR facility.

(4) Localizer Systems.

(i) Flight test requirements may be modified to allow for adequate antenna radiation pattern measurements as discussed under VOR paragraph b(3)(i) flight test.

(ii) The signal input to the receiver presented by the antenna system should be of sufficient strength to keep the malfunction indicator out of view when the rotorcraft is in the approach configuration and at least 10 NM from the station. This signal should be received for 360 degrees of rotorcraft heading at all bank angles up to 10 degrees left or right at all normal pitch altitudes, and at an altitude of approximately 2,000 feet.

(iii) The deviation indicator should properly direct the aircraft back to course when the rotorcraft is right or left of course.

(iv) The station identification signal should be of adequate strength and sufficiently free from interference to positive station identification, and voice signals should be intelligible with all electric equipment operating and pulse equipment transmitting.

(v) Localizer performance should be checked for rotor modulation in approach while varying rotor RPM throughout its normal range.

(A) Localizer Intercept. In the approach configuration and a distance of at least 10 NM from the localizer facility, fly toward the localizer front course, inbound, at an angle of at least 50 degrees. Perform this maneuver from both left and right of the localizer beam. No flags should appear during the time the deviation indicator moves from full deflection to oncourse. If the total antenna pattern has not been shown by ground checks or by VOR flight evaluation to be adequate, additional intercepts should be made.

(B) Localizer Tracking. While flying the localizer inbound and not more than 5 miles before reaching the outer marker, change the heading of the rotorcraft to obtain full needle deflection. Then fly the rotorcraft to establish localizer on course operation. The localizer deviation indicators should direct the rotorcraft to the localizer on course. Perform this maneuver with both a left and a right needle deflection. Continue tracking the localizer until over the transmitter. At least three acceptable front course and back course flights should be conducted to 200 feet or less above threshold.

(5) Glide Slope Systems.

(i) Flight Test. The signal input to the receiver should be of sufficient strength to keep the warning flags out of view at all distances to 10 NM from the facility. This performance should be demonstrated at all aircraft headings from 30 degrees left to 30 degrees right of the localizer course. The deviation indicator should properly direct the aircraft back to path when the aircraft is above or below path. Interference with the navigation operation should not occur with all rotorcraft equipment operating

and all pulse equipment transmitting. There should be no interference with other equipment as a result of glide slope operation.

(ii) Glide Slope Intercept. While flying the localizer course inbound in level flight, intercept the glide slope below path at least 10 NM from the station. Observe the glide slope deviation indicator for proper crossover as the aircraft flies through the glide path. There should be no flags from the time the needle leaves the full scale fly-up position until it reaches the full scale fly-down position.

(iii) Glide Slope Tracking. While tracking the glide slope, maneuver the aircraft through normal pitch and roll attitudes. The glide slope deviation indicator should show proper operation with no flags. At least three acceptable approaches to 200 feet or less above threshold should be conducted.

(iv) Interference. With all rotorcraft electrical equipment operating and all pulse equipment transmitting, determine that there is no interference with the glide slope operation (some interference from the VHF may be acceptable), and that the glide slope system does not interfere with other equipment.

(v) Glide slope performance should be checked for rotor modulation during the approach while varying rotor RPM throughout its normal range.

(6) Marker Beacon System.

(i) The marker beacon annunciator light should be illuminated for a period of time representing 2,000 to 3,000 feet distance when flying at an altitude of 1,000 feet as it passes over a marker beacon (see table below).

Altitude = 1,000 feet (AGL)

Ground Speed Light Time (Seconds)

<u>Knots</u>	<u>2,000 feet</u>	<u>3,000 feet</u>
90	13	20
110	11	16
130	9	14
150	8	12

(ii) The audio signal should be of adequate strength and sufficiently free from interference to provide positive identification.

(iii) Technical: Approach the markers at a ground speed of 130 knots and at an altitude of 1,000 feet above ground level. While passing over the outer and middle markers with the localizer deviation indicator centered, the annunciators should be

illuminated for a period of 9 to 14 seconds. Check for acceptable intensity of the indicator lights in bright sunlight and at night. For slower rotorcraft, the interval should be proportionately longer.

NOTE: It is recognized that the normal altitude at the middle marker is on the order of 150 to 200 feet. Due to variations in both glide slope angle and position of the middle marker in relation to the runway, the on glide path marker width will vary considerably which in turn will give a widely varying light time. Therefore, the more clearly defined criteria at 1,000 feet altitude should be used for quantitative testing of the middle marker function.

(7) Automatic Direction Finding Equipment (ADF).

(i) Range and Accuracy. The ADF system installed in the rotorcraft should provide operation with errors not exceeding 5 degrees and the aural signal should be clearly readable up to the distance listed for any one of the following types of radio beacons:

(A) 50 NM from an H facility (transmitter power 50-2,000 watts).

(B) 25 NM from an MH facility (transmitter power less than 50 watts).

(C) 15 NM from a compass locator (transmitter power less than 25 watts).

(ii) Needle Reversal. The ADF indicator needle should make only one 180-degree reversal when the rotorcraft flies over a radio beacon. This test should be made both with and without the landing gear extended.

(iii) Indicator Response. When switching stations with relative bearings differing by approximately 175 degrees, the indicator should indicate the new bearing within ± 5 degrees within 10 seconds.

(iv) Antenna Mutual Interaction. For dual installations, there should not be excessive coupling between the antennas.

(v) Technique.

(A) Range and Accuracy. Tune in a number of radio beacons spaced throughout the 200 - 415 kHz range and located at distances near the maximum range for the beacon (see (a) Range and Accuracy). The identification signals should be clear and the ADF should indicate the approximate direction to the stations. Beginning at a distance of at least 15 NM from a compass locator in the approach configuration, fly inbound on the localizer front course and make a normal ILS approach. Evaluate the aural identification signal for strength and clarity and the ADF for proper performance with the receiver in the ADF mode. All electrical equipment on the aircraft should be operating and all pulse equipment should be transmitting. Fly over a ground check

point with relative bearings to the facility of 0, 45, 90, 135, 180, 225, 270, and 315 degrees. The indicated bearings to the station should correlate within 5 degrees.

(B) Needle Reversal. Fly the aircraft over an H, LOM, or LMM facility at an altitude of 1,000 to 2,000 feet above ground level. The indicator needle should make only one reversal.

(C) Indicator Response. With the ADF indicating station dead ahead, switch to a station having a relative bearing of approximately 175 degrees. The indicator should indicate within ± 5 degrees of the bearing in not more than 10 seconds.

(D) Antenna Mutual Interaction. If the ADF installation being tested is dual, check for coupling between the antennas by using the following procedure.

(1) With #1 ADF receiver tuned to a station near the low end of the ADF band, tune the #2 receiver slowly throughout the frequency range of all bands and determine whether the #1 ADF indicator is adversely affected.

(2) Repeat (A) with #1 ADF receiver tuned to a station near the high end of the ADF band.

(8) Distance Measuring Equipment (DME).

(i) The DME system should:

(A) Continue to track without dropouts when the rotorcraft is maneuvered throughout the air space within 100 NM of the VORTAC station and at altitudes from the radio line of sight to the maximum altitude for which the rotorcraft is certificated. This tracking standard should be met with the rotorcraft in the cruise configuration, at bank angles up to 10 degrees, climbing and descending at normal maximum climb and descent attitude, and orbiting a DME facility.

(B) Provide clearly readable identification of the DME facility.

(C) DME operation should not interfere with other systems aboard the rotorcraft (some interference with the transponder may be acceptable) and DME operation should not be adversely affected by other equipment.

(D) DME Hold.

The DME should continue to operate and track when DME Hold is activated and the channel switch is varied.

(E) DME Override. When an override switch is provided, proper operation should be demonstrated.

(ii) Technique.

(A) Climb and Maximum Distance. Determine that there is no mutual interference between the DME system and other equipment aboard the rotorcraft. Beginning at a distance of at least 10 NM from a DME facility and at an altitude of 2,000 feet above the DME facility, fly the rotorcraft on a heading so that the aircraft will pass over the facility. At a distance of 5 to 10 NM beyond the DME facility, operate the rotorcraft at its normal maximum climb attitude up to an altitude of 7,000 feet maintaining the aircraft on a station radial (within 5 degrees). The DME should continue to track with no unlocks to a range of 100 NM. Record the maximum altitude flown.

(B) Long Range Reception. Perform two 360 degree turns, one to the right and one to the left, at a bank angle of 8 to 10 degrees at least 100 NM from the DME facility. A single turn will be sufficient if the antenna installation is symmetrical. There should be no more than one unlock not to exceed one search cycle (maximum 35 seconds) in any 5 miles of radial flight.

(C) Penetration. From an altitude of above 7,000 feet (AGL) perform a let-down directly toward a ground station (DME facility) at a normal maximum rate of descent so as to reach an altitude of 5,000 feet above the DME facility 5 to 10 NM before reaching the DME facility. The DME should continue to track during the maneuver with no unlocks.

(D) Approach. Make a normal approach to land at a field with a DME located on the airport. The DME should track without an unlock (station passage excepted).

(E) DME Hold. With the DME tracking, activate the DME hold function. Change the channel selector to a localizer frequency. The DME should continue to track on the original station.

(9) Transponder Equipment.

(i) Performance Criteria. The ATC transponder system should furnish a strong and stable return signal to the interrogating radar facility when the rotorcraft is flown in straight and level flight throughout the air space within 100 NM of the radar station from radio line of sight to within 90 to 100 percent of the maximum altitude for which the rotorcraft is certificated. The airborne system should be controllable so that objectionable ring-around, spoking and clutter will not persist. The transponder system should not interfere with other systems aboard the rotorcraft and other equipment should not interfere with the operation of the transponder system (some interference from DME operation may be acceptable). When the rotorcraft is flown in the following maneuvers within the air space described above, the dropout time should not exceed 20 seconds.

(A) In turns at bank angles up to 10 degrees.

(B) Climbing and descending at normal maximum climb and descent attitude.

(C) Orbiting a radar facility.

(ii) Technique.

(A) Climb and Distance Coverage: Beginning at a distance of at least 10 NM from and at an altitude of 2,000 to 3,000 feet above that of the radar facility and using a transponder code assigned by the ARTCC, fly on a heading that will pass the rotorcraft over the facility. At a distance of 5 to 10 NM beyond the facility, operate the rotorcraft to maintain an altitude above radio line of sight while maintaining the aircraft at a heading within 5 degrees from the radar facility to 100 NM from the radar facility.

(B) Communicate with the ground radar personnel for evidence of transponder dropout. During the flight, check the "ident" mode of the ATC transponder to assure that it is performing its intended function. Determine that the transponder system does not interfere with other systems (except possibly the DME) aboard the rotorcraft and that other equipment (except possibly the DME) do not interfere with the operation of the transponder system. There should be no dropouts, that is, when there is no return for two or more sweeps. The operation of the ATC transponder should be verified over the station, at 25 NM, and at 100 NM.

(C) Long Range Reception. Perform two 360-degree turns, one to the right and one to the left, at bank angles of 8 to 10 degrees with the flight pattern at least 100 NM from the radar facility. During these turns, the radar display should be monitored and there should be no signal dropouts (two or more sweeps).

(10) Weather Radar Equipment.

(i) Bearing Accuracy. The indicated bearing of objects shown on the display should be within 5 degrees of their actual magnetic bearing within the sectors 40 degrees right and left of the aircraft longitudinal axis. Beyond 40 degrees right and left, bearing accuracy should be ± 10 degrees.

(ii) Distance of Operation. The radar should be capable of displaying prominent targets throughout the distance and angular range of the display.

(iii) Antenna Stabilization. When antenna stabilization is provided, it should eliminate blurring of the display for the ranges of pitch and roll for which it is designed.

(iv) Beam Tilting. The radar antenna should be installed so that its beam is adjustable to any position between 10 degrees above and 10 degrees below the plane of rotation of the antenna.

(v) Technique.

(A) Bearing Accuracy. Fly under conditions which allow visual identification of a target, such as an island, a river, or a lake, at a range within 10 percent of the maximum range of the radar. When flying toward the target, select a course that will pass over a reference point from which the bearing to the target is known. When flying a course from the reference point to the target determine the error in displayed bearing to the target on all range settings. Change heading in increments of 10 degrees and determine the error in the displayed bearing to the target.

(B) Contour Display (Iso Echo). If heavy cloud formations or rainstorms are reported within a reasonable distance from the test base, select the contour display mode. The radar should differentiate between heavy and light precipitation. In the absence of the above weather conditions, determine the effectiveness of the contour display function by switching from normal to contour display while observing large objects of varying brightness on the indicator. The brightest objects should become the darkest when switching from normal to contour mode.

(C) Stability. While observing a target return on the radar indicator, turn off the stabilizing function and put the aircraft through pitch and roll movements. Observe the blurring of the display. Turn the stabilizing mechanism on and repeat the roll and pitch movements. Evaluate the effectiveness of the stabilizing function in maintaining a sharp display.

(D) Ground Mapping. Fly over areas containing large, easily identifiable landmarks such as rivers, towns, islands, coastlines, etc. Compare the form of these objects on the indicator with their actual shape as visually observed from the cockpit.

(E) Mutual Interference. Determine that no objectionable interference is present on the radar indicator from any electrical or radio/navigational equipment when operating, and that the radar installation does not interfere with the operation of any of the rotorcraft's radio/navigational systems.

(11) Area Navigation. Advisory Circular 90-45A is the basic criteria for evaluating an area navigation system, including acceptable means of compliance to the FAR.

(12) Inertial Navigation. Advisory Circular 25-4, Inertial Navigation Systems, is the basic criteria for the engineering evaluation of an inertial navigation system (INS) and offers acceptable means of compliance with the applicable Federal Aviation Regulations which contain mandatory requirements in an objective form. The engineering evaluation of an INS should also include awareness of Advisory Circular 121-13, Self-Contained Navigation Systems (Long Range), which presents criteria to be met before an applicant can get operational approval. For flights up to 10 hours, the radial error should not exceed 2 nautical miles per hour of operation on a 95 percent statistical basis. For flights longer than 10 hours, the error should not

exceed ± 20 NM crosstrack or ± 25 NM along track error. A 2-nautical-mile radial error is represented by a circle, having a radius of 2 nautical miles, centered on the selected destination point.

(13) Doppler Navigation. Doppler navigation system installed performance should be evaluated in accordance with Advisory Circular 121-13. (See FAR 121, Appendix G).

(14) Radio Altimeters. Radio altimeter system installed performance should be evaluated in accordance with RTCA Document DO-123, Appendix A, Part II.

(15) Emergency Locator Transmitters (ELT).

(i) Emergency locator transmitter performance should be evaluated in accordance with TSO-C91. ELT installations should be examined for potential operational problems. There have been numerous instances of interaction between ELT and other VHF installations. ELT antenna installations in close proximity to other VHF antennas should be suspect. Antenna patterns of previously installed VHF antennas should be measured after an ELT installation. Some problems caused by ELT installations are:

(A) Loss of radiated power from VHF communications.

(B) Reradiation of VHF transmitter energy such that navigation crosspointers are affected.

(C) Reception of FM broadcast, at high level, in VHF communications.

(D) Inadvertent activation of the ELT by VHF transmitted energy. (See AD 72-22-3.)

(ii) ELT Installation. TSO-C91 specifies that the ELT be automatically activated when subjected to a force of 5.0 (+2,-0)g in the direction of the longitudinal axis of the aircraft. This recommendation for mounting is considered satisfactory for rotorcraft. In recognition of the significant vertical impact velocity that rotorcraft commonly have an optional placement of the ELT pitched down 30° from the horizontal axis of the rotorcraft is also satisfactory.

(16) Audio Interphone Systems. Acceptable communications should be demonstrated for all audio equipment including microphones, speakers, headsets, and interphone amplifiers. All modes of operation should be tested, including operation during emergency conditions (i.e., emergency descent, and oxygen masks) with all rotorcraft engines running, all rotorcraft pulse equipment transmitting, and all electrical equipment operating.

(17) Portable Battery Powered Megaphones (AC 121-6). Megaphone performance should be evaluated in accordance with AC 121-6.

(18) Omega and Omega/VLF Navigation Systems. Omega and Omega/VLF Navigation systems should be evaluated in accordance with the following AC's that apply to the type of approval requested:

(i) AC 120-37, Approval of Omega Systems, as a sole means of overwater long range navigation.

(ii) AC 120-31A, Approval of Airborne Omega Navigation Systems, as a means of updating self-contained navigation systems.

(iii) AC 20-101B, Approval of Omega and Omega/VLF Navigation.

(19) Rotorcraft Condition Monitoring System Installations.

(i) General. Avionics equipment and systems are being installed in rotorcraft to collect data to be used in assessing engine/rotorcraft performance and frequency of maintenance. Some of the items monitored are engine operating exceedances, hot starts, power assurance, and cycle counts. The monitoring systems being addressed by this paragraph are those used to collect data for maintenance purposes not those monitors which are utilized as part of the control system for autopilot/flight controls or engine controls. At present, optional approvals are being requested for most of these systems not performing any required functions. However, most of the applicants anticipate requesting approval for the systems to be used in the future to perform some required function or to allow required maintenance to be predicated on the operation of the system. This consideration becomes particularly important if the system is software based. A further discussion of system software is included in paragraph AC 29 MG 1 b(19)(iii)(B).

(ii) System Installation. The system installation should be shown to be free from hazards considering both normal operation and possible malfunctions. Malfunctions which might be caused by software errors are discussed under paragraph AC 29 MG 1 b(19)(iii)(B). The accuracy and response of the monitoring device/system should be sufficient to allow the operational and maintenance personnel to relate the data obtained to required maintenance actions. The exceedance (engine limit) information being acquired by these systems is or will be used in place of information previously acquired from field reports of operational personnel utilizing the basic aircraft instruments. In this case, the automated system will generally produce results which are more accurate than the basic aircraft instruments. However, in this circumstance, it is not appropriate to require the monitor system to be more accurate than the previously approved methods used to provide the required exceedance data. If the data collected by the system require filtering prior to use, it is equally acceptable to accomplish this filtering either as the data are being acquired (airborne function) or

when the data are analyzed (ground based function) and used in the maintenance of the rotorcraft.

(iii) System Components.

(A) Hardware. The hardware of the system when operating under the control of the imbedded software should be shown to comply with § 29.1301. Additionally, in showing compliance to § 29.1309(a), laboratory testing to the appropriate portions of the latest revision of RTCA Document DO-160 should be performed.

(B) Software. If the function of the monitor system depends on embedded airborne software to determine all or part of its functioning, Document DO-178 is the recommended standard to be used for the approval of the system software. A further discussion of the use of this document is included in paragraph AC 29.1309. The selection of the software level should be carefully considered because system approval is sometimes initially sought on the basis of the system being a non-required optional system. If it has further been shown that no dependence is made on the system software to preclude a hazardous failure mode, then a low software level would be acceptable. However, it is very difficult to qualify software to higher levels of "quality" once the software has been initially certified. Because of this, it is recommended that the software be chosen to the level consistent with the ultimate use to which approval of the system is planned. If the system is to be approved only as non-required optional equipment, then the choice of a low level of software qualification may be appropriate. However, when more experience is gained with the operation of the system, and it is ultimately planned to seek approval to perform required functions, then an appropriate higher level of software should be initially obtained.

NOTE: Extensive service experience should not be considered as a basis for level of criticality without accomplishing RTCA DO-178 procedures.

(20) Night Vision Goggles (NVG).

(i) Background. Night vision goggles (NVG) have been used by U.S. military pilots since the early 1970's. The first units (first generation or GEN I) were constructed from the rifle "Sniper-Scopes." These units did not provide much light amplification. The second generation (GEN II) were still primarily designed for ground use. Second generation high performance units (military designation AN/PVS-5C) had some consideration for flight use but were still lacking in several aspects. A light level of at least a quarter moon well above the horizon was required for operation of these NVG. At first the normally helmet-mounted units covered the pilot's entire upper face and the pilot could only see through the NVG. In order to protect the light amplification system these NVG had an automatic shutoff feature when brighter than relatively low levels of light were encountered. Normal incandescent and especially red incandescent lights would cause these NVG to shut down. Aircraft cockpit lights, especially the red warning lights, would cause "blooming" (an increased brightness of all or portions of the NVG

field of view with the disappearance of the "picture" in that area) or a total shutdown of the NVG. Military aircraft cockpits and lighting systems were significantly modified to avoid this problem. In the late 1980's the military pushed technology for better and aircraft compatible NVG. Third generation (GEN III, military designation ANVIS or AN/AVS-6) NVG systems became available about 1988. These systems require only star light for satisfactory operation.

(ii) Procedures. As of January 1990, no approvals for civil rotorcraft operations with NVG have been issued. Since NVG are not installed in the rotorcraft, they are not required to be approved as part of the type design. However, since an operational approval would be required for use of NVG, they should meet some acceptable performance standard. The minimum standard recommended is the GEN III NVG. The performance of these NVG are rated as their spectral response to irradiated light sources, measured as density of incident photons per square meter. Third generation, AN/AVS-6, NVG have been evaluated for compatibility with a limited number of rotorcraft and were generally found to be usable during en route operations with no cockpit lighting systems modifications. It is anticipated, however, that some aircraft may require significant modifications to the existing cockpit lighting system. The FAA/AUTHORITY policy is that modification of the cockpit to a non-compliant configuration to accommodate NVG use is not acceptable. For instance, alteration of the required red warning annunciators to some other color is not acceptable. Since individual rotorcraft may have been modified with additional lights or systems, each rotorcraft being considered for use with NVG should be evaluated by an FAA/AUTHORITY representative during a night flight. If it is anticipated that cockpit lighting system modifications will be required to achieve an adequate level of NVG compatibility FAA/AUTHORITY involvement should be arranged as soon as possible. Preferably this evaluation flight would be made with two pilots or a pilot and safety observer, over a known area, where all the aircraft and cockpit lights are operated and their effect on the NVG determined. Reflections of landing or searchlights on windshields or other glass during approach or landing may affect NVG and may impose a minimum altitude restriction for use of NVG. Failure of the NVG should be evaluated during any critical flight phase.

Note that the above discussion is purposely limited in scope. Issues such as crew training and operating limitations would have to be addressed in detail to obtain an operational approval.

(21) Rotorcraft Health and Usage Monitoring Systems (HUMS).

(i) General. HUMS can be divided into two major categories: Health Monitoring Systems and Usage Monitoring Systems. The provisions of § 29.1301 are used to determine that the system performs its intended function. The provisions of § 29.1309(a) and (b) are used to look at the impact of environmental conditions and malfunctions. To date (mid-1990) HUMS have not been approved to replace service life or other specific physical limits but several systems are now in the process of seeking approval. Health monitoring systems are considered to be the serious applications of

this technology, and it will probably be some time before the necessary data base to allow full reliance on this technology is available. There have been numerous approvals of usage monitoring systems as optional equipment, and a good example of this technology is a condition monitoring system described in paragraph AC 29 MG 1b(19) above.

(ii) Health Monitoring Systems.

(A) It is anticipated these systems will begin as "optional" systems in order to build a data base to support expansion of the approval to achieve credit for extension of maintenance intervals, and so forth. Systems range from low to high integrity requirements depending on the determined criticality of application.

(B) Some systems that are being considered will utilize off aircraft processing of data. If this is to be pursued it should be assumed that the aircraft data will be lost or misplaced at the processing center, and the aircraft system design should consider this possibility. Some on-board data storage is one way to account for this lost data. The integrity of the processing center's software should be equal to that of the aircraft software. In addition the intervals for processing the data from each flight should be specified as part of the approval.

(C) Due to the limited experience with these systems it is suggested the issue paper process be utilized to record the progress of the approval, and to provide information for later updating of this AC material.